The island of drive

Representations, somatic states and the origin of drive

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Funding / potential competing interests: No financial support and no other potential conflict of interest relevant to this article were reported.

Summary

Freud defined the drive as "a concept on the frontier between the mental and the somatic". Today this view that was based on clinical observations interpreted within the psychoanalytical framework, can be revisited in light of the current neuroscientific notions of neuronal plasticity and somatic states. Indeed, through the mechanisms of plasticity experience leaves a trace that forms the neural basis of a representation of the experience. Such a representation R is associated with a somatic state S in the sense taken from the "somatic marker" model of Damasio. Thus, the internal reality of the subject, particularly the unconscious one, is constituted by such connected R's and S's. In the model that we discuss, the posterior insula represents the primary interoceptive cortex where information about somatic states S converges, while in the anterior insula the connection between R and S can take place and establish a neurobiological correlate for the notion of drive. We posit that the re-representations of S associated with R in the anterior insula may correspond to the *Vorstellungsrepräsentanz* postulated by Freud. We further propose that the tension between R and S established in the anterior insula is discharged according to the notion of drive through the motor arm of the limbic system, namely the anterior cingulate cortex which is heavily connected with the anterior insula.

Key words: insula; anterior cingulate cortex; drive; somatic states; Vorstellungsrepräsentanz; Freud

Introduction

Freud defined *drive* as "a concept on the frontier between the mental and the somatic", more specifically as "the psychical representative of the stimuli originating from within the organism" [1]. In keeping with this definition, the drive, according to the psychoanalytical theory, plays a role in the actions enacted by the subject. The drive that underlies the act of the subject originates from the unconscious and therefore the motivation of the action of the subjects remains unknown and often surprising. This origin of the action is to be contrasted with the decision process, which predominantly belongs to the domain of consciousness (fig. 1).

Experience leaves a trace in the neuronal networks through the mechanisms of plasticity, resulting in the establishment of an internal reality, which is both conscious and unconscious. The latter engages a particular form of plasticity, the process of reconsolidation and trace re-association, which establishes a kind of discontinuity between experience and traces. The unconscious results from such a discontinuity [2] (fig. 2).

As already formulated by William James and more recently by Antonio Damasio, somatic states play a central role in emotions and in the decision process. We have proposed that for each experience that produces a representation R through the mechanisms of plasticity, a representation of the somatic state S is also associated with it. The representations that constitute the internal reality, be it conscious or unconscious, are therefore associated with somatic states, thus establishing a strong association between R and S (fig. 3) [2, 3].

According to this model, drive is the unconscious counterpart of the decision process (fig. 1). Indeed, the somatic markers theory of Damasio [4, 5] proposes that decisions rely on the anticipation of the somatic state in which the act produced by the decision will affect the subject. Drive can be viewed as an "unconscious decision process" which emanates from the association of a somatic state and an unconscious representation, or fantasy [6] (fig. 1). The acts that derive from either decision or the drive will be perceived by the subject and contribute to their own becoming (fig. 1).

One can postulate that any S associated with an R potentially represents a deviation from the homeostatic state (fig. 4). Thus, like any physiological process, as interestingly proposed also by the inertia principle of the psychoanalytical theory [7], a pressure for re-establishing the homeostatic state will emerge. However, because the somatic state S is associated with a representation R, the re-establishment of homeostasis will be constrained by the content of the representation R and therefore engage an action related to it. Thus, the origin of the act related to the drive, depends on the nature of the representation R that is associated with the somatic state S (fig. 4).

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Sensing the somatic states: the interoceptive system

What is meant with the term somatic state? Which are the neuronal circuits that mediate their perception? All organisms are exposed to stimuli that originate both from the external world but also from the interior of the body. Exteroceptive sensory systems such as vision, hearing, olfaction or touch detect stimuli which originate from the external world. In contrast, the interoceptive system provides the means to detect the general state of the body, the *Gemeingefühl* of the German literature. This system informs the brain about the state of viscera, glands and smooth muscles.

While the physiology of the exteroceptive system has been the object of intensive investigation over the last century, only recently has attention been given to the physiology of the interoceptive system, in particular thanks to the pioneering work of Bud Craig [8, 9]. The interoceptive system is organised in a way such that fibres enter the posterior horn of the spinal cord and progress towards higher brain centres. These fibres are of small diameter and only partially myelinated or even unmyelinated; hence their conduction velocity is relatively slow, in the order of 1 meter per second. Such fibres are similar to the A Delta and C fibres which transmit nociception. After a first synapse in the posterior horn, the interoceptive fibres cross to the other side of the spinal cord and ascend towards brainstem nuclei and in humans, they progress to specific thalamic nuclei.

From the thalamus, these fibres project to a specific cortical area, the insula, which can be considered as the interoceptive primary cortex. The insula, a kind of "island", is located at the interior aspect of the frontal lobes and is anatomically and functionally divided into an anterior and a posterior division. Interoceptive information is therefore conducted through this ascending system terminating in

Figure 1
Through the mechanisms of plasticity the representations of experience associated with somatic states, constitute the conscious and unconscious internal realities of the subject. From the tension between the representations and somatic states both *drive*, at the unconscious level, and *decision*, at the conscious level, will emerge. The actions produced by these processes are perceived by the subject.

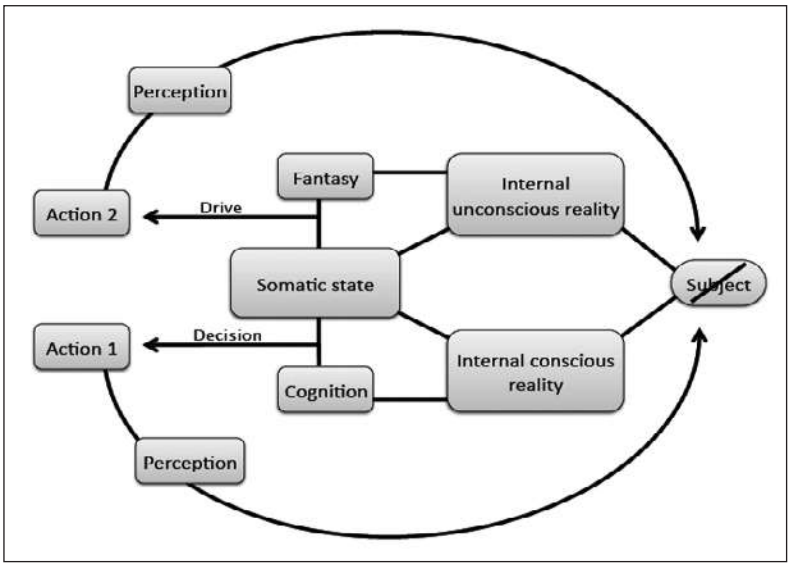


Figure 2
Reassociation of traces left by experience through the mechanisms of plasticity will produce new traces, hence a new representation, that are no longer in direct relationship with the original experience. This process of trace reassociation results in a discontinuity which contributes to the establishment of the unconscious.

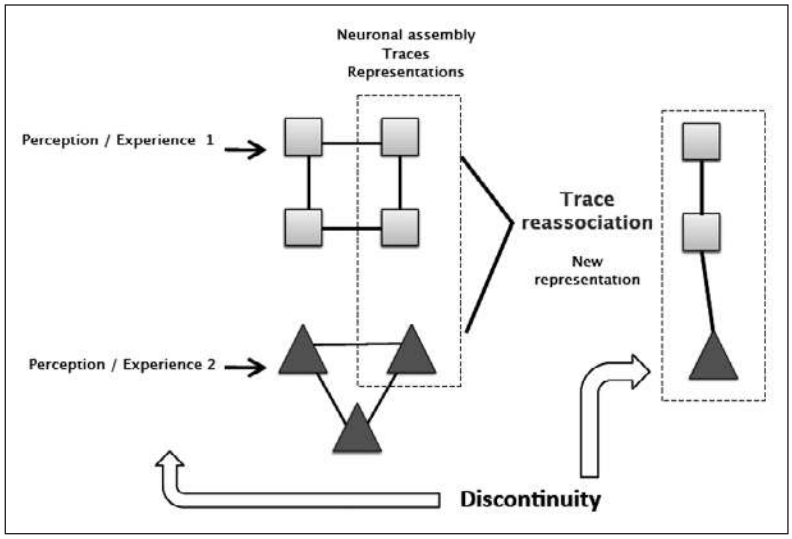


Figure 3
The somatic state S associated with perception, will "mark" the representation R of the perception.

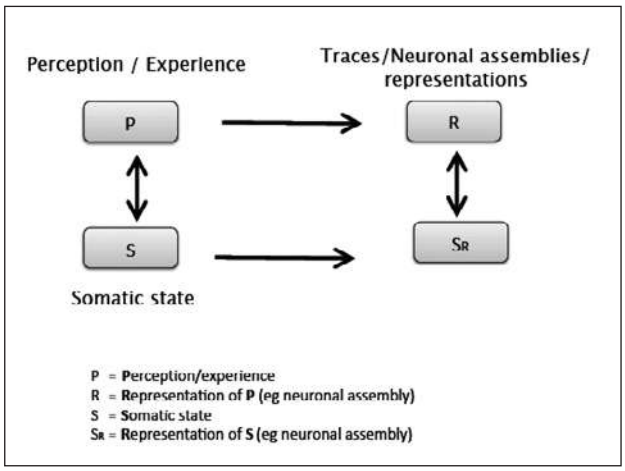


Figure 4
The homeostatic drive that results from the tension between R and S is discharged in an act that re-establishes homeostasis.

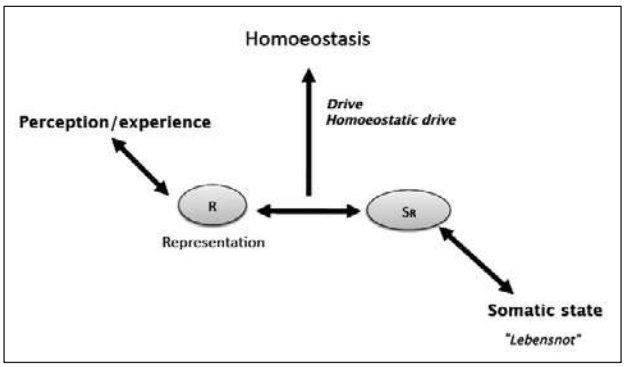


Figure 5 Simplified schematic of the afferent interoceptive pathway that carries the sensory information originating from the viscera, and the efferent pathway of the autonomic nervous system (motor) which modify the somatic states by acting on the viscera.
The hypothalamus also contributes to these homeostatic loops that contribute to the maintenance of homeostasis. These loops (grey arrows) which in the figure appear below the horizontal line, essentially function in a reflex manner. In higher primates and in particular in humans, these regulatory loops (black arrows) extend to the thalamus, the insula and the anterior cingulated cortex (loops above the horizontal line). This extension implies a mentalisation of the homeostatic regulations.

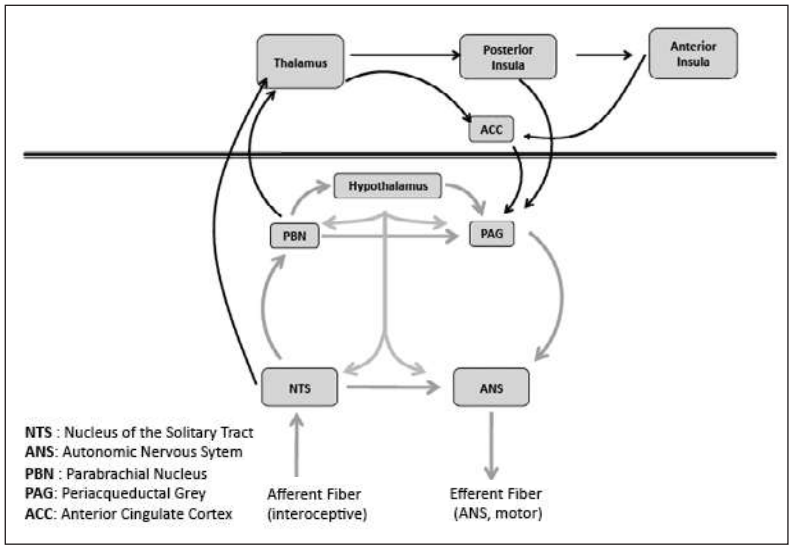
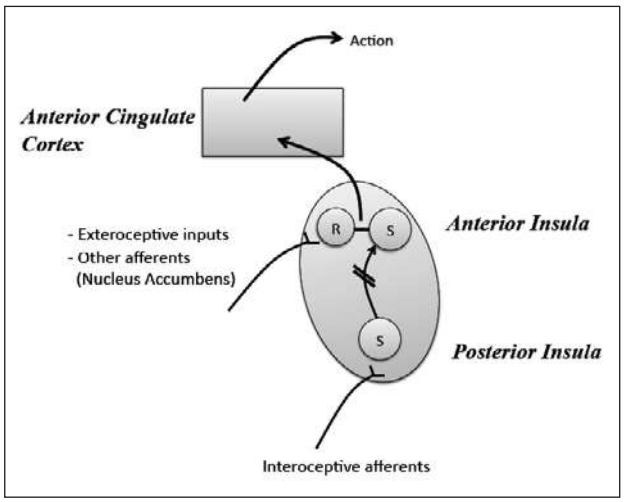


Figure 6
Relationship between the posterior insula (primary representations of the somatic states), the anterior insula (re-representations which integrate exteroceptive information as well as other inputs involved in motivation such as those originating in the nucleus accumbens) and the anterior cingulate cortex (executive functions).



the posterior insula. This interoceptive system shares some analogies with the somatosensory system which projects from the skin to a primary sensory area, in the parietal cortex. A first function of this interoceptive system is to contribute, along with the automatic nervous system, to the maintenance of bodily homeostasis. The balance between the two divisions of the autonomic nervous system, namely the sympathetic and the parasympathetic divisions, which exert opposite effects, ensures the maintenance of homeostasis and the physiological adjustment of the vital functions of the organism, thus contributing to the maintenance of organism's integrity. These effector systems which originate in the nuclei of the brainstem and in the intermediolateral horn of the spinal cord, represent the motor branch of a reflex loop, of which the sensory arm is represented by the interoceptive afferents (fig. 5).

This sensory–motor loop allows for the execution of fine physiological adjustments that contribute to the maintenance of the bodily homeostasis. Functional connections between the sensory (interoceptive) and motor (autonomic nervous system) arms of this sensory–motor loop, occur at different levels of the nervous system, notably at the spinal cord and brainstem levels. Other reciprocal connections exist between nuclei in the brainstem and the hypothalamus, contributing to the overall maintenance of bodily homeostasis. Therefore, there exists mechanisms which can be defined as being "automatic" or "reflex" between the sensory and motor arm of this homeostatic system. These reflex relationships clearly exist at lower levels of the nervous systems such as the spinal cord, the brainstem and the hypothalamus and do not engage the contribution of higher levels of the nervous system (fig. 5).

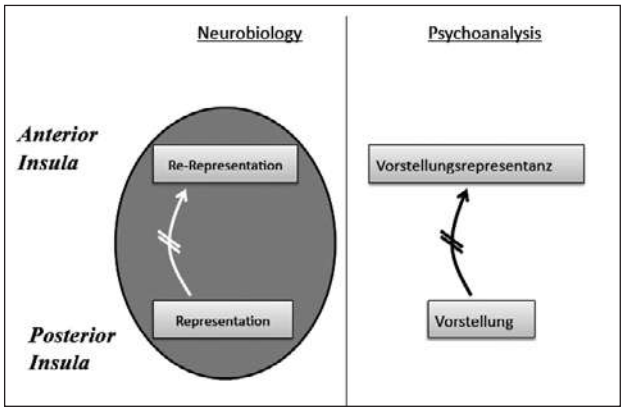
However, in humans, the maintenance of the bodily homeostasis does not engage only these reflex regulations, but also involves more complex behaviours which mobilise areas of the brain involved in higher brain functions and in particular in executive functions. Even simple behaviours such as food seeking, or the search for a sexual partner, imply the interplay between motivation, anticipation of pleasure or displeasure and reward, which are based on conscious processing such as decision making, and at the unconscious level by drive.

Beyond the automatic regulation of homeostasis: humans vs animals

In humans, the homeostatic regulation mediated by the interoceptive system goes beyond the reflex level operated at the spinal cord, brainstem and hypothalamic levels. Indeed, the interoceptive system establishes synaptic relays in the thalamus and terminates in the posterior insula (fig. 5). A representation of the bodily states is established in the posterior and dorsal insula, which is itself strongly connected with other brain regions involved in motivated behaviours such as the anterior cingulate cortex or the nucleus accumbens, the latter being involved in reward mechanisms. Thus, it appears that the extension of the interoceptive system beyond the brainstem is a characteristic of primates, in particular humans. It is therefore important to underline this fundamental difference between humans and other species.

In lower species, homeostasis is re-established in a reflex manner, without mentation. In contrast, in humans, the information originating from the body constitutes a primary representation in the posterior insula, which is then associated with other representations in secondary re-representa-

Figure 7 Proposal for the correspondence between the notions of representation (posterior insula) and re-representation (anterior insula) (neurobiology) and on the other side, the notion of *Vorstellung* and *Vorstellungsrepräsentanz* (psychoanalysis).



tions. This results in a mode of homeostatic regulation which involves considerably more freedom by escaping automatic and reflex regulation. The primary representation of the bodily states occurs in the posterior insula; this primary representation would then integrate information originating from other sensory areas at the level of the anterior insula (fig. 6). This process results in a re-representation of the bodily states [8]. Thus, at a given point in time, the primary representation of the bodily states would be contextualised with other information originating from other sensory areas. The information originating from the outside world, through the exteroceptive systems, be integrated with information originating from the body and vehiculated to the anterior insula (fig. 6).

This type of integration is similar to what also occurs for the exteroceptive systems, where the primary representations of the external stimuli occur in primary sensory areas. These primary representations are then integrated with other information at the level of secondary sensory areas, which allow the contextualising of the significance of the primary stimulus.

Are the re-representations in the anterior insula the neurobiological equivalent of the Freudian *Vorstellungsrepräsentanz*? [10]

This notion of re-representation of the somatic states is also a key concept in the psychoanalytical theory. Freud proposes the existence of a first representation of the living matter, which would in fact correspond to the physiological state of the body, he defines this as *Vorstellung*. This *Vorstellung* would then be the object of a second representation for which he proposes the term of *Vorstellungsrepräsentanz*, which is the representative of representation. In Freud's view, the *Vorstellungsrepräsentanz* is a kind of ambassador [11] who represents the living matter in a way similar to the way in which an ambassador represents the interests of his country in its interactions with foreign nations (fig. 7).

The biological data concerning the interoceptive system support the existence of a re-representation in the anterior insula of the somatic state that was initially represented in the posterior insula. In the case of the anterior insula, the "foreign countries", would in fact be representations of the other sensory exteroceptive modalities which provide a context and associate with the representative of the somatic state detected by the interoceptive pathways. The anterior insula would therefore be a site where the integration of the representation R of experience with the representations of the somatic states S occurs (fig. 6). Thus the anterior insula would be a level at which representations of the external world and their representations R would become associated with the representations of the somatic states S. One should not view this association occurring in the anterior insula as a strict localisation but rather as the crossroads of a dynamic process.

The motor aspect of drive

In the psychoanalytical theory, the fundamental destiny of the drive produced by the tension between R and S is its discharge, which can only be operated by the execution of an act, implying a motor aspect to the drive (fig. 4). Functional imaging studies have shown that the anterior insula is often co-activated with the anterior cingulate cortex. The interest of this observation lies in the fact that the anterior cingulate cortex is strongly implicated in motor acts, in executive functions. This region of the brain plays a central role in what is known in neuropsychological theories as the motivation of the action. Neuroanatomical as well as functional studies indicate therefore a strong connection between the anterior insula and the anterior cingulate cortex. In fact these two regions are considered the sensory arm (anterior insula) and the motor arm (anterior cingulate cortex) of the limbic system. The anterior cingulate cortex also receives information concerning the bodily states through the interoceptive system (fig. 5). Furthermore, the anterior insula and the anterior cingulate cortex are connected by a particular type of neuron which is found exclusively in humans, the neurons of Von Economo. It is interesting to note that in frontotemporal dementia, a neurodegenerative disease which affects primarily frontal regions, and in particular Von Economo neurons, patients present an emotional indifference and apathy which results in an inability to initiate actions.

This connectivity between the anterior insula and the anterior cingulate cortex would imply that the neuronal assemblies which code the representations R and the associated somatic state S, at the level of the anterior insula, can simultaneously activate neurons in the anterior cingulate cortex in order to initiate an action (fig. 6). Thus, from a psychoanalytical point of view, one can postulate that this kind of connectivity would participate in the process of discharge of the drive and its contribution to the maintenance of homeostasis.

Drive and self-consciousness

We have proposed a parallel between the drive and decision making, the first one emanating from unconscious represen-

tations or fantasies, while the second from conscious ones (fig. 1). While Freudian *drive* implies the discharge of the excess of living matter (*Lebensnot*, fig. 4), associated with the somatic state S through the mental content embedded in the representation R, one can state again that the association between R and S occurs dynamically at the level of the anterior insula and that the discharge by the action occurs at the level of the anterior cingulate cortex at least partially through the connections operated by the Von Economo neurons. Since drive is discharged through an action, the subject perceives this action via the exteroceptive systems such as vision or hearing (fig. 1). While perceiving this act, the subject is informed of the external manifestation of the somatic state at the origin of the drive.

In other words and quite surprisingly, our internal bodily states would manifest themselves with a slight temporal delay through the drive, therefore revealing our somatic state through the perception of the act. The subject is then divided by the act (fig. 1).

Extending this viewpoint has implications also for self-consciousness. Perception of the somatic states at the level of the posterior insula through the activity of the interoceptive system, but in particular its re-representation in the anterior insula, can contribute to the concept of self-consciousness [8]. However, the perception of the action of the subject, produced by the drive, introduces a more dynamic aspect in the emergence of self-consciousness. Self-consciousness may also receive the impact of drive. Thus self-consciousness does not appear to be only related to cognitive processes in which interoception and the perception of the body play a key role. Self-consciousness integrates also aspects that include the dimension of the drive, and therefore indirectly of the unconscious.

References

1 Freud S. Instincts and their vicissitudes. In: Strachey J, editor. The Standard Edition of the Complete Psychological Works of Sigmund Freud. Vol. XIV. London: Hogarth Press; 1957. p. 121–2.
2 Ansermet F, Magistretti P. Biology of Freedom. Neural Plasticity, Experience, and the Inconscious. New York: Other Press; 2007.
3 Ansermet F, Magistretti P. Les énigmes du plaisir. Paris: Odile Jacob; 2010.
4 Damasio AR. The somatic marker hypothesis and the possible functions of the prefrontal cortex. Philos Trans R Soc Lond B Biol Sci. 1996;351(1346):1413–20.
5 Damasio AR. Decartes' Error. Emotion, Reason, and the Human Brain. New York: Putnam; 1994.
6 Ansermet F, Magistretti P. An unexpected phone call. How drives originate and what becomes of them. In: Biology of Freedom. New York: Other Press; 2007. p. 133–46.
7 Arminjon M, Ansermet F, Magistretti P. The homeostatic psyche: Freudian theory and somatic markers. J Physiol Paris. 2010;104(5):272–8.
8 Craig AD. How do you feel – now? The anterior insula and human awareness. Nat Rev Neurosci. 2009;10(1):59–70.
9 Craig AD. Interoception: the sense of the physiological condition of the body. Curr Opin Neurobiol. 2003;13(4):500–5.
10 The English translation of Vorstellungsrepräsentanz is "ideational representative" (Freud S. The unconscious. In: Strachey J, editor. The Standard Edition of the Complete Psychological Works of Sigmund Freud. Vol. XIV. London: Hogarth Press; 1957. p. 177).
11 Lacan J. The Four Fundamental Concepts of Psycho-Analysis, 1964. Harmondsworth: Penguin Books; 1979. p. 220.